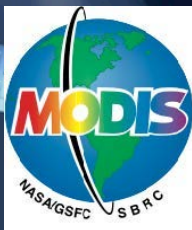


Integrating Multi-Platform Satellite Soil Moisture and Evapotranspiration Retrievals to Constrain Water and Energy Balance Coupling

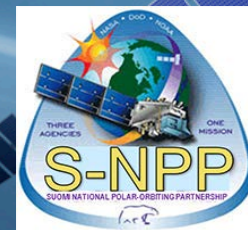
Wade T. Crow, Fangni Lei, Martha C. Anderson
Hydrology and Remote Sensing Laboratory, USDA ARS

Thomas R. H. Holmes
Hydrological Sciences Laboratory, NASA GSFC

Christopher Hain
Earth Science Office, NASA MSFC

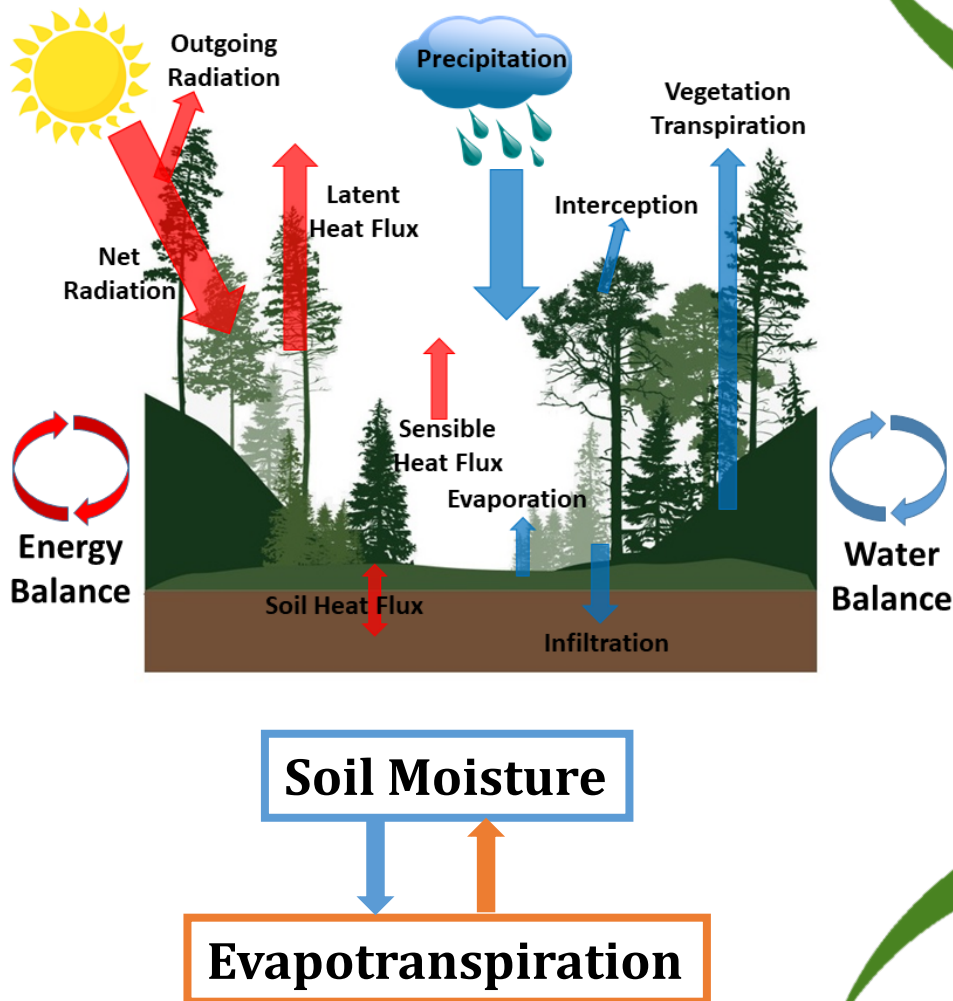


October 15-19, 2018
MODIS/VIIRS Science Team Meeting
MODIS Land Science Analysis

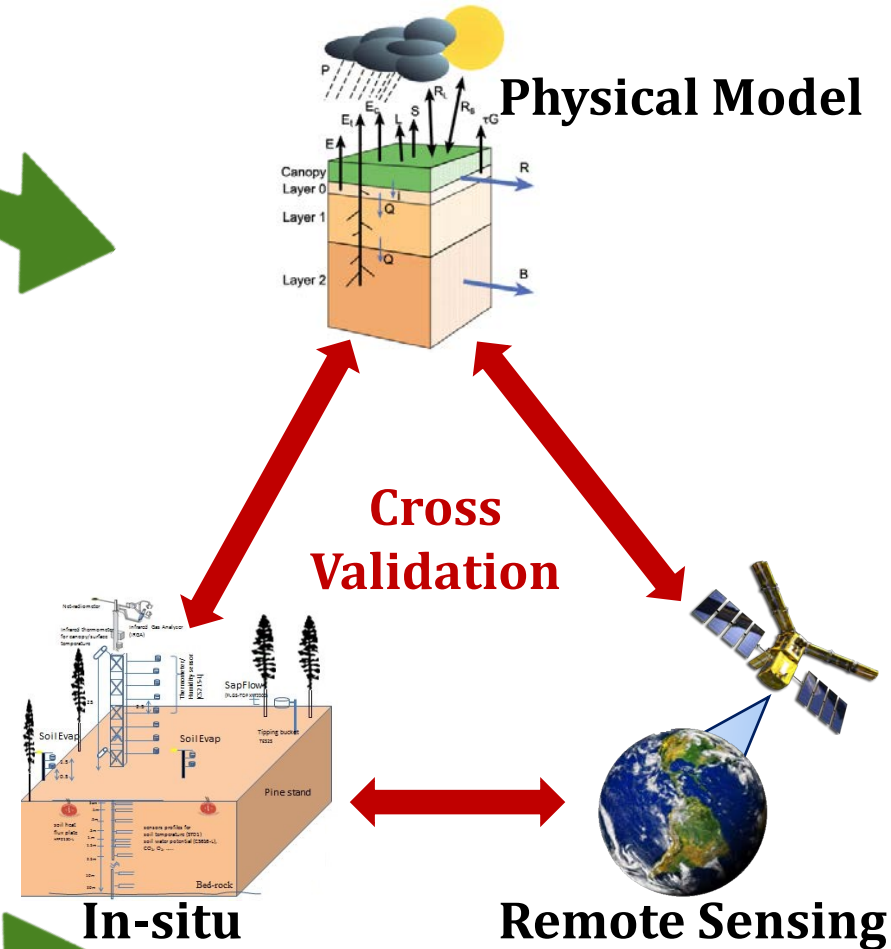


Motivation – Water and Energy Balance Coupling

Land-Atmosphere Interaction



Physical Model



Motivation – Multi-Platform Remote Sensing

☐ Meteorological Information

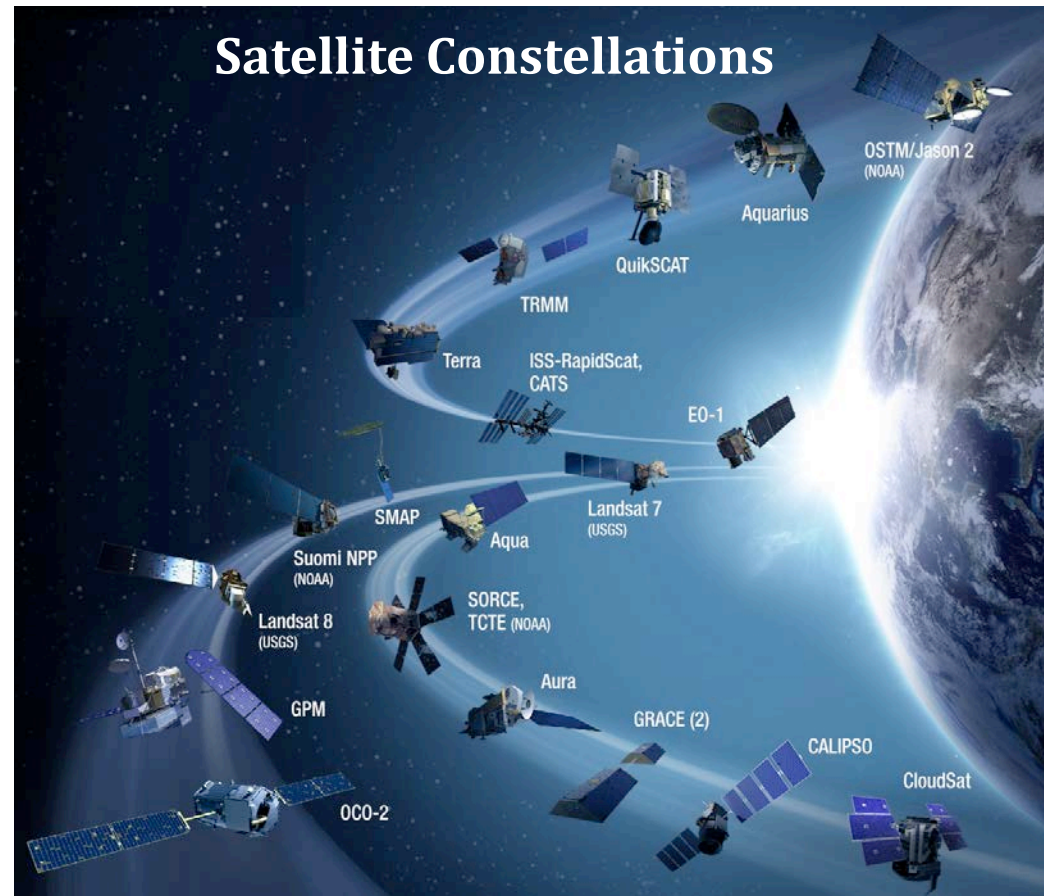
- ✓ Solar insolation
- ✓ Precipitation
- ✓ Atmospheric temperature
- ✓ Wind speed
- ✓ Humidity

...

☐ Land Surface Characteristics

- ✓ Soil moisture
- ✓ Land surface temperature
- ✓ Leaf area index
- ✓ Landcover type

...



Multi-platform satellite soil moisture and evapotranspiration products

Motivation – Improving the Understanding

Here comes the question...

 Are current land surface models accurate in characterizing the relation between soil moisture and evapotranspiration?

Key challenge:

 Coupling estimates obtained from (relatively noisy) satellite retrievals are biased.

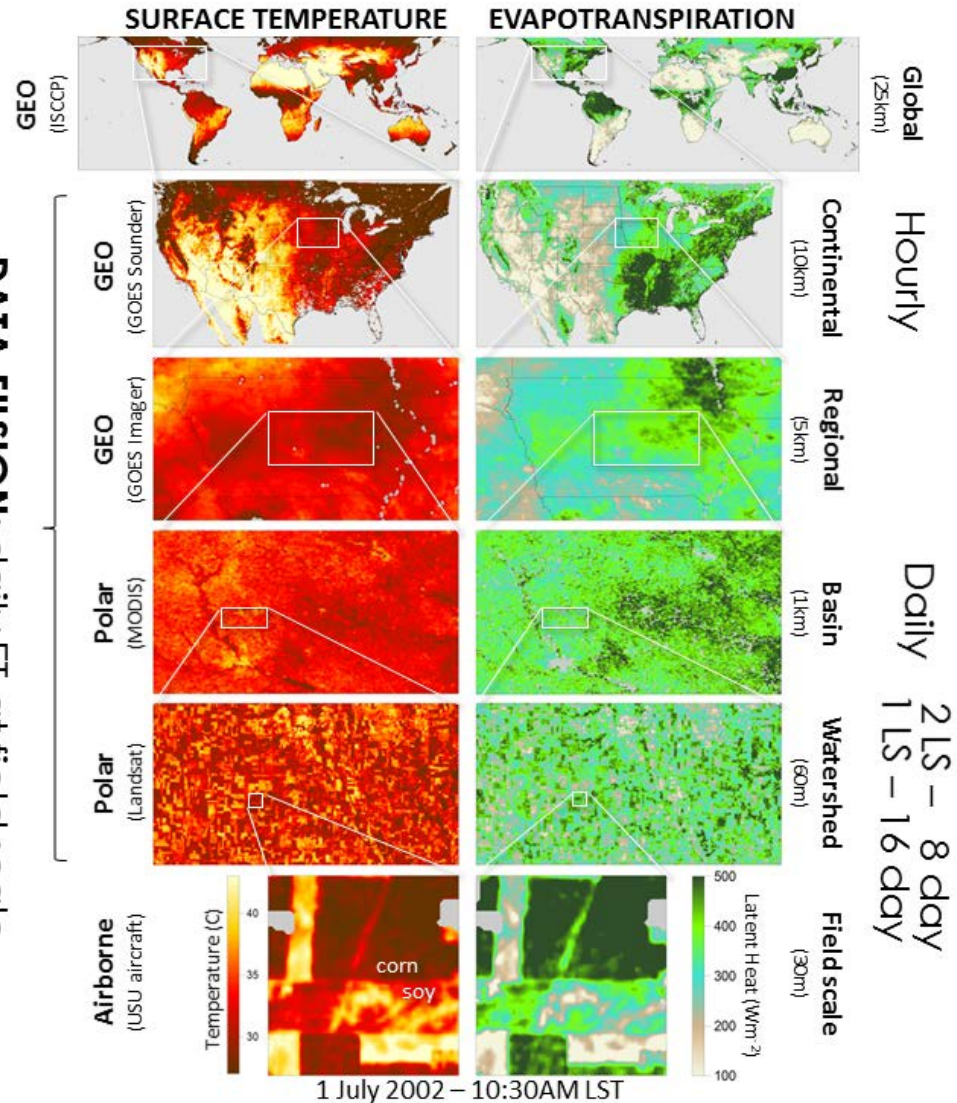
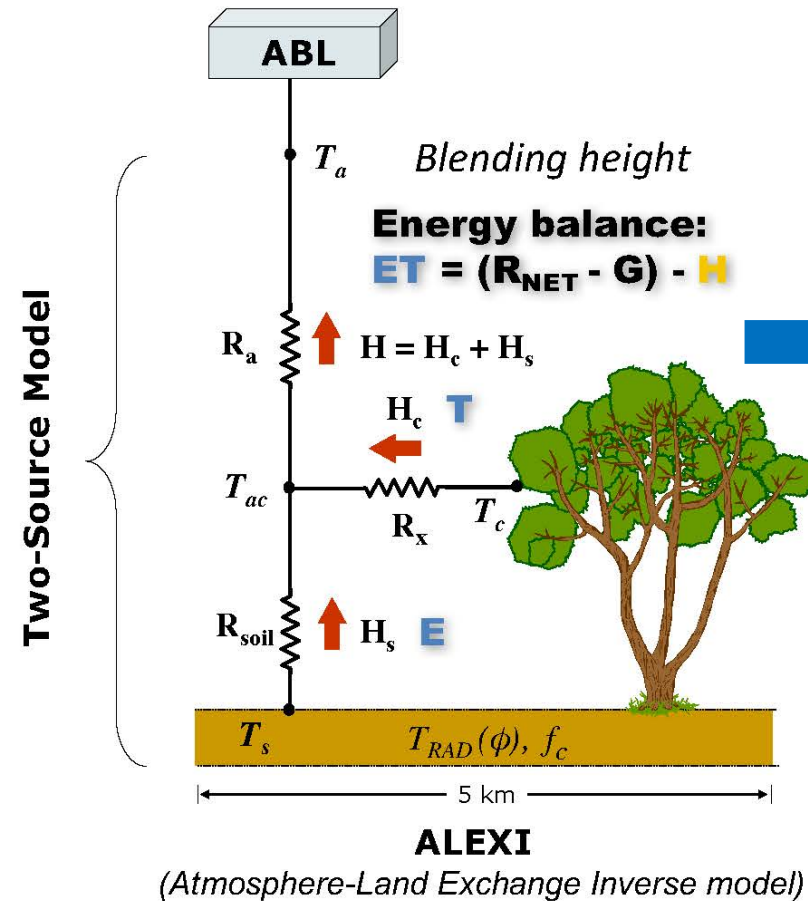
Our approach:

 Obtain unbiased, observation-based global estimates of true coupling by integrating multi-platform soil moisture and evapotranspiration retrievals



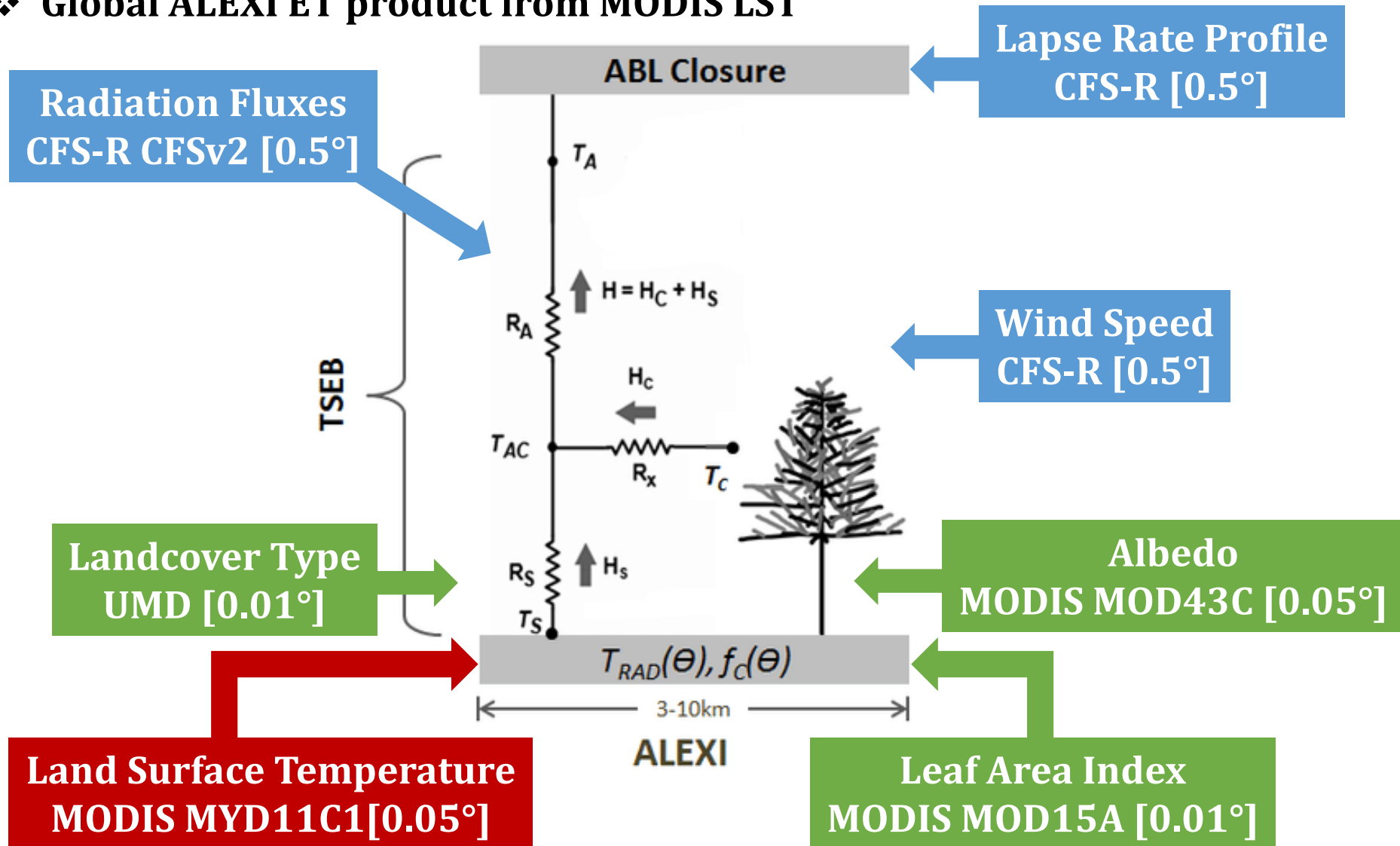
Multi-Platform Land Products – Evapotranspiration

Atmosphere-Land Exchange Inverse



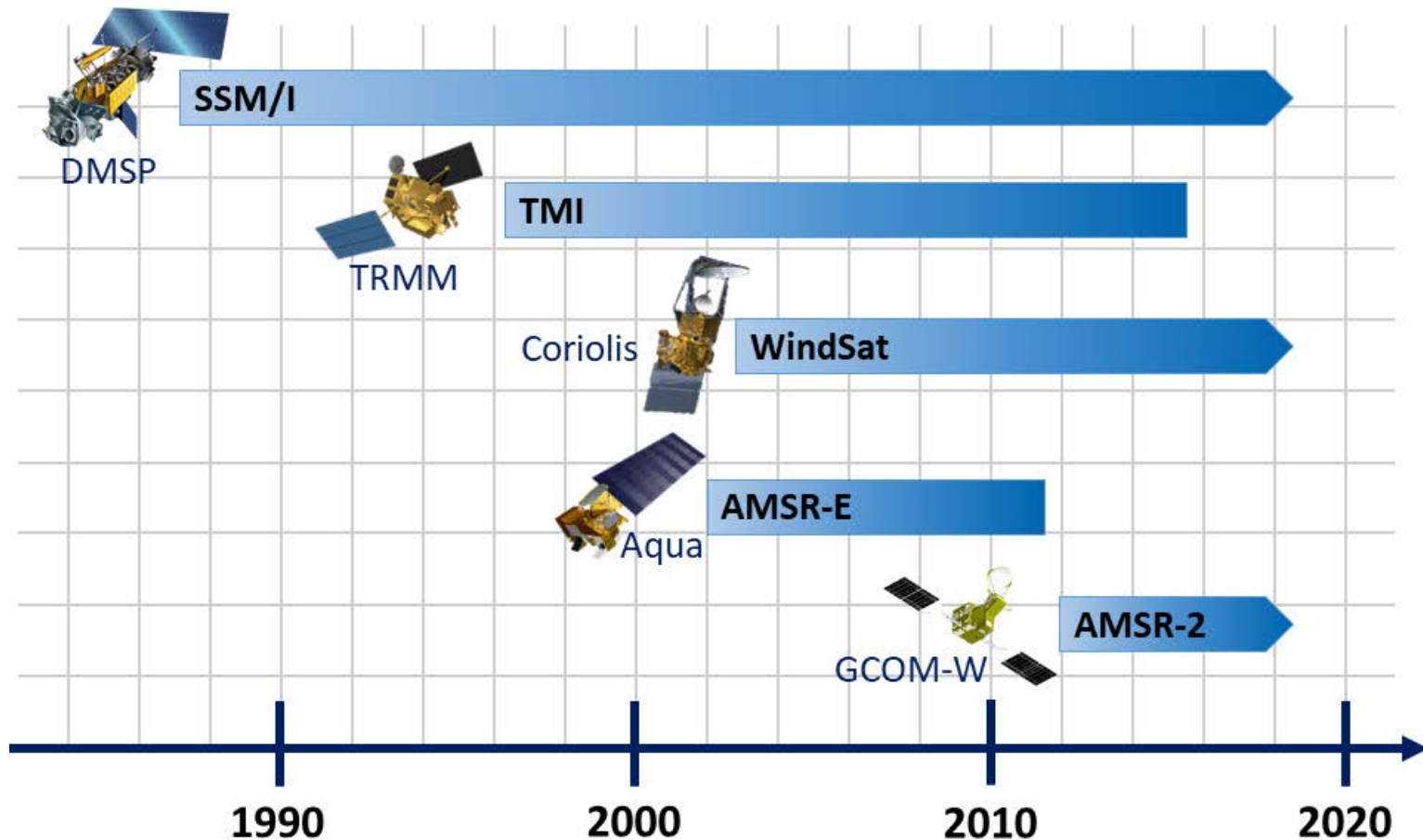
Multi-Platform Land Products – Evapotranspiration

❖ Global ALEXI ET product from MODIS LST



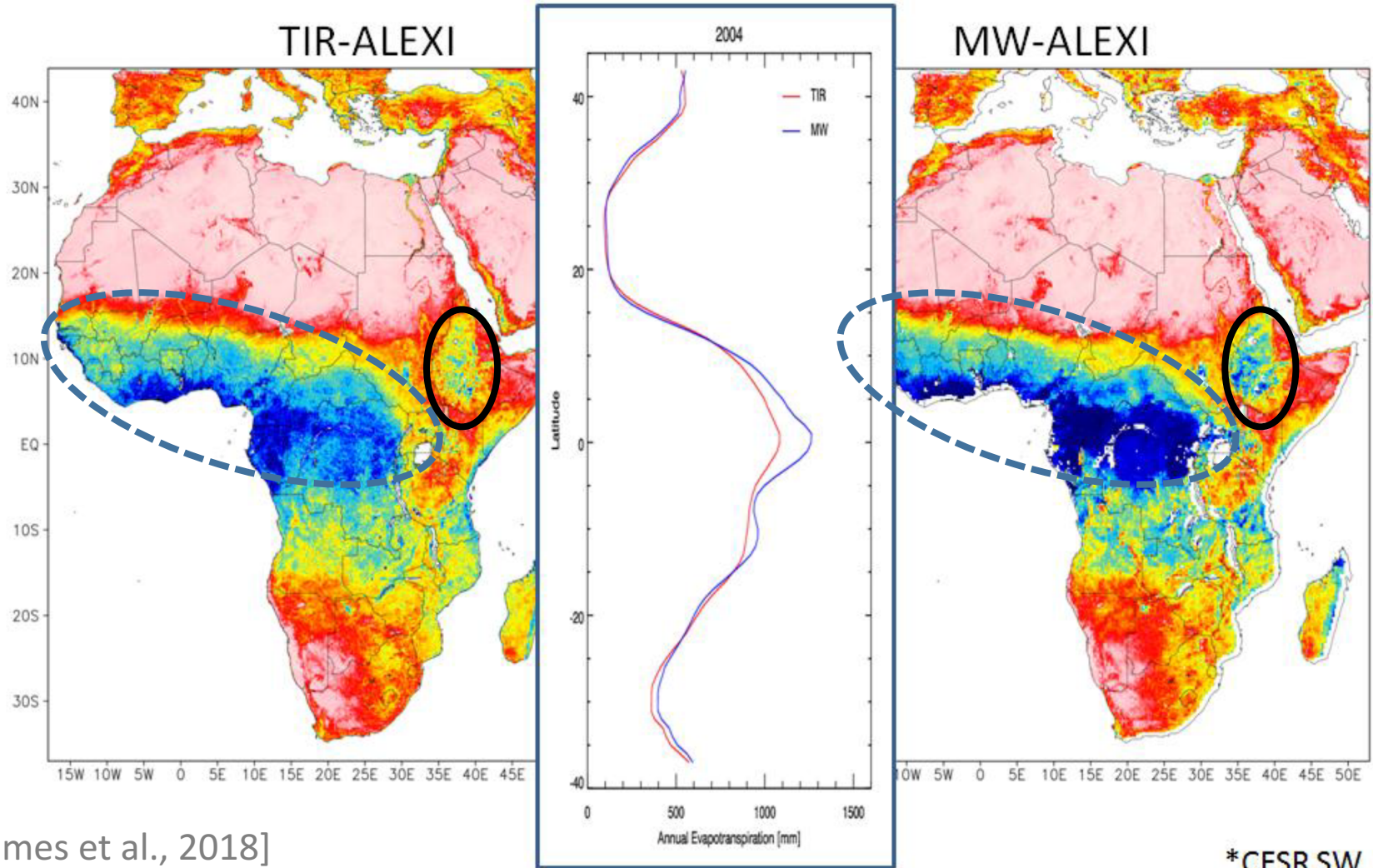
Multi-Platform Land Products – Evapotranspiration

❖ MW-LST retrievals from Ka-band satellite sensors



Multi-Platform Land Products – Evapotranspiration

Cumulative - Clear Sky - Evapotranspiration (mm)
2004

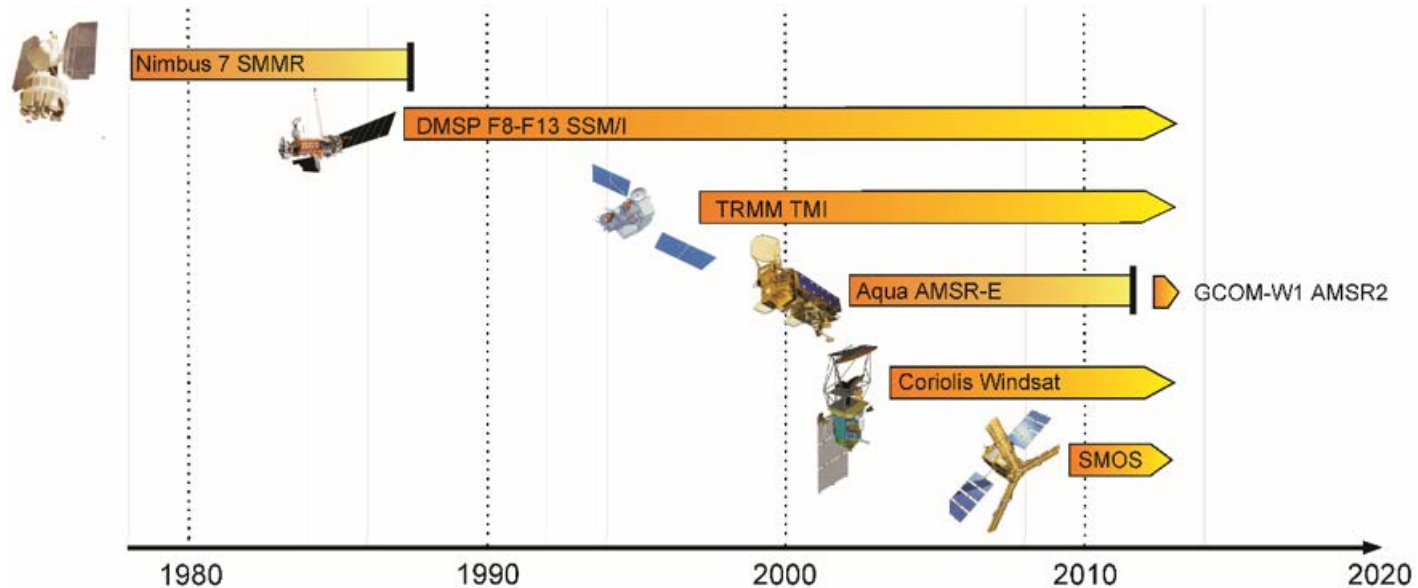


[Holmes et al., 2018]

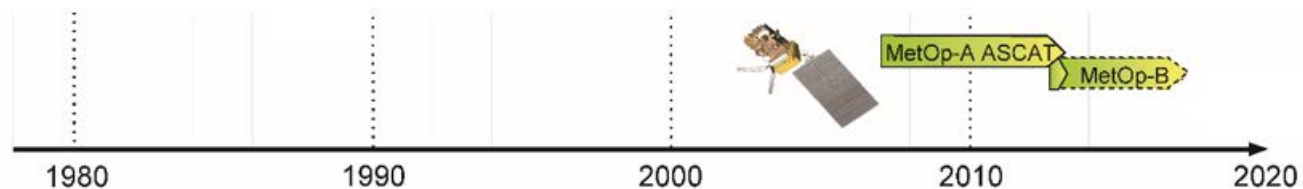
*CFSR SW

Multi-Platform Land Products – Soil Moisture

ESA CCI merged passive microwave soil moisture

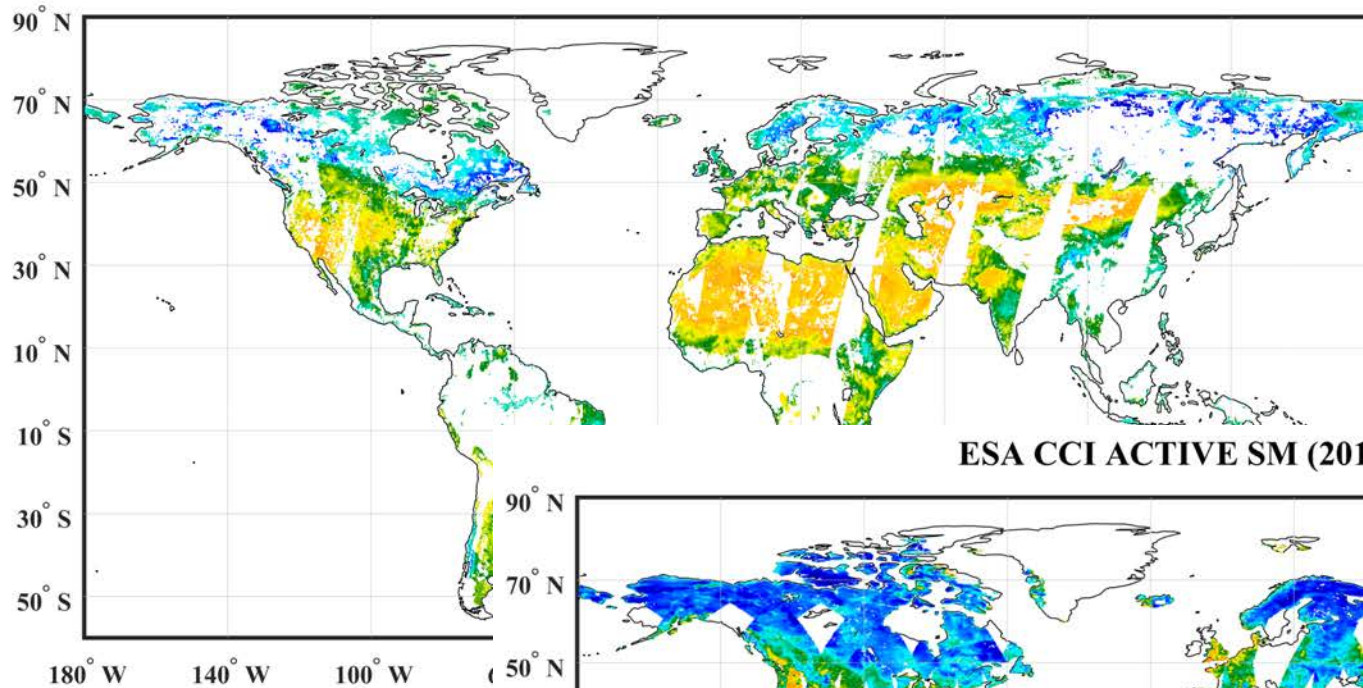


MetOp-A/B ASCAT active microwave soil moisture



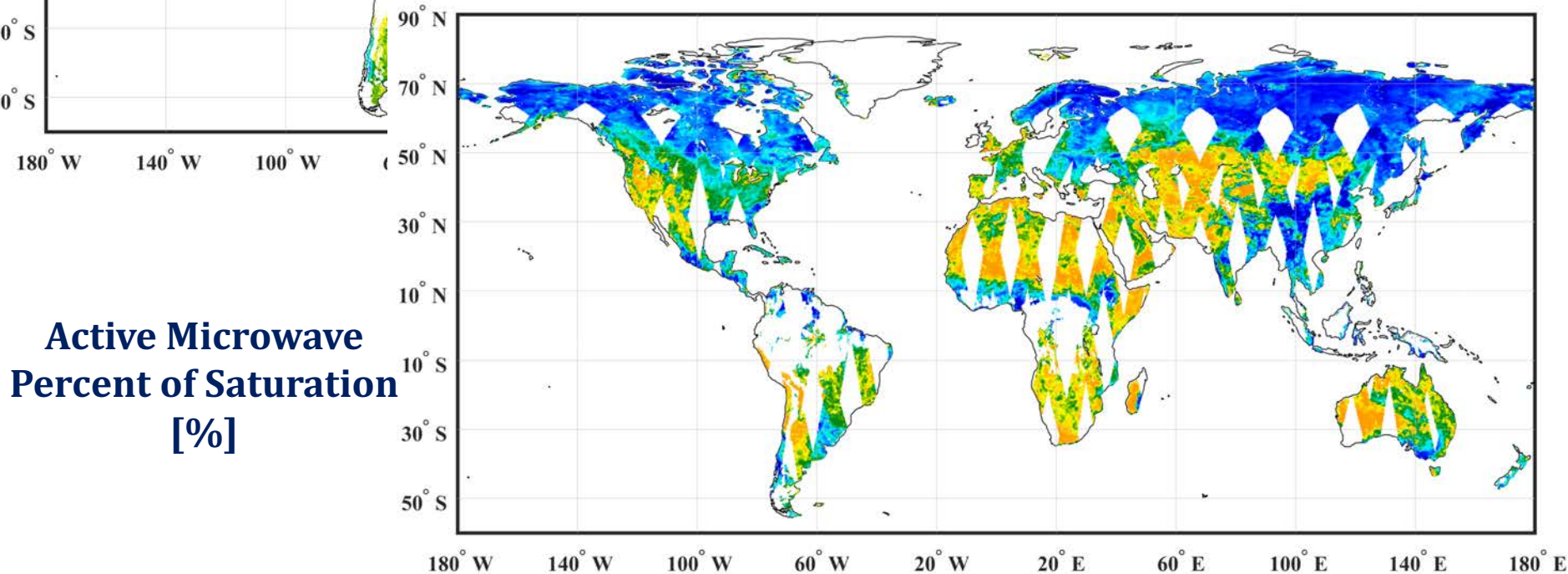
Multi-Platform Land Products – Soil Moisture

ESA CCI PASSIVE SM (2010/07/01)



**Passive Microwave
Soil Moisture**
 $[m^3/m^3]$

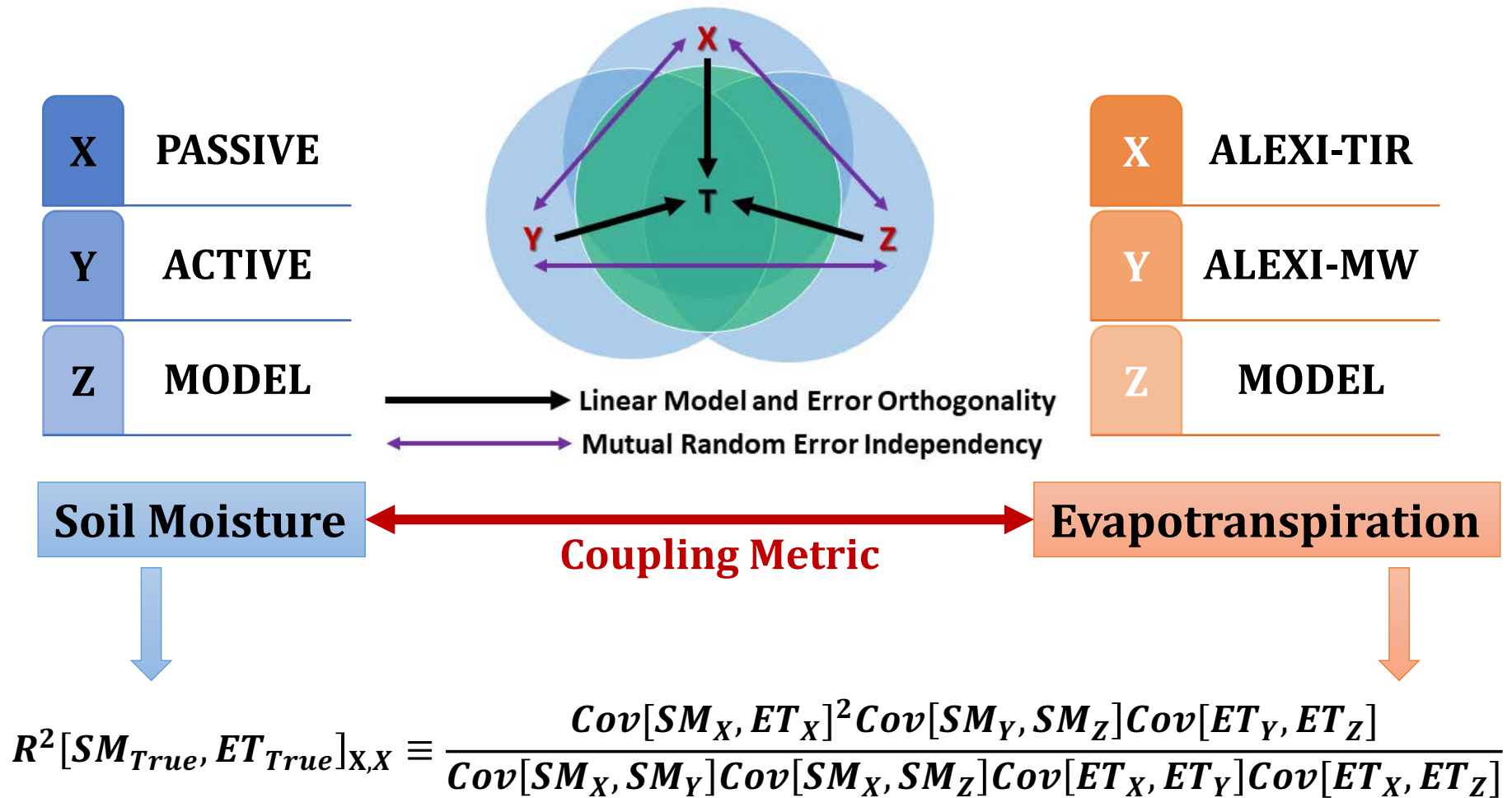
ESA CCI ACTIVE SM (2010/07/01)



**Active Microwave
Percent of Saturation**
[%]

A Unified Approach to Integrate Products

Triple collocation-based coupling strength metric



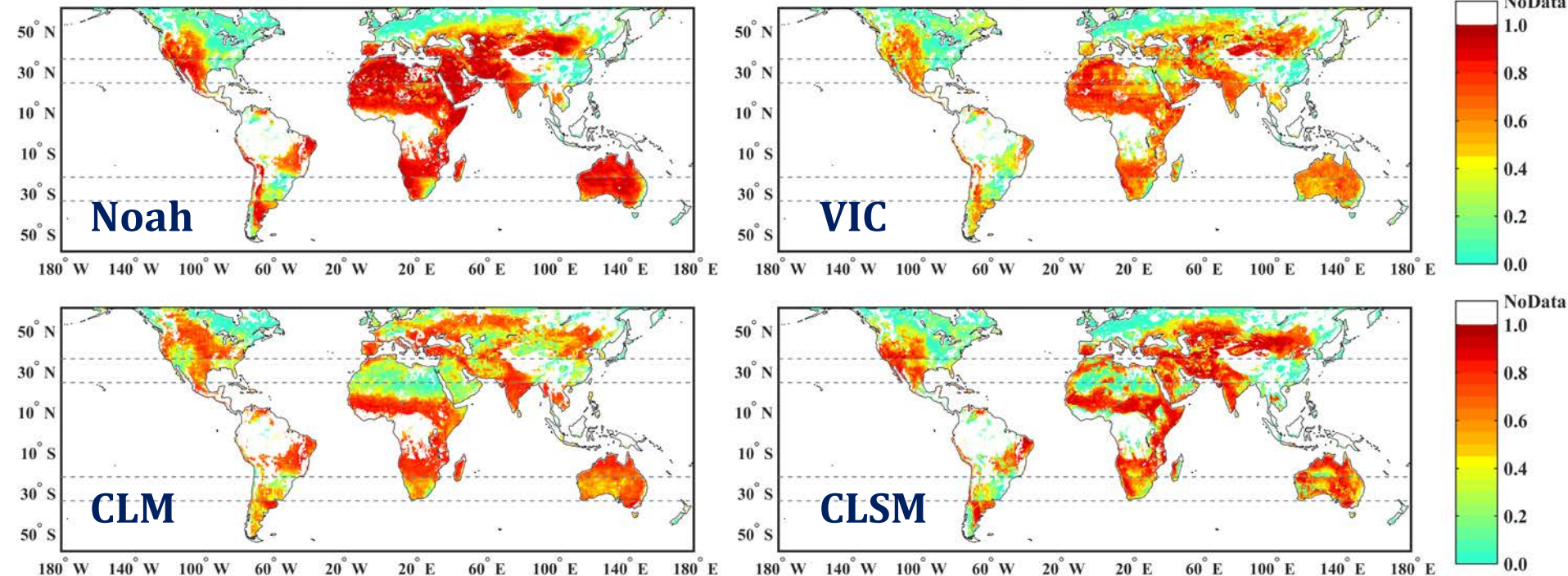
Discrepancy among Land Surface Models

Global Land Data Assimilation System

- Noah v3.3
- Community Land Model (CLM) v2.0
- Variable Infiltration Capacity (VIC)
- Catchment Land Surface Model (CLSM) F2.5



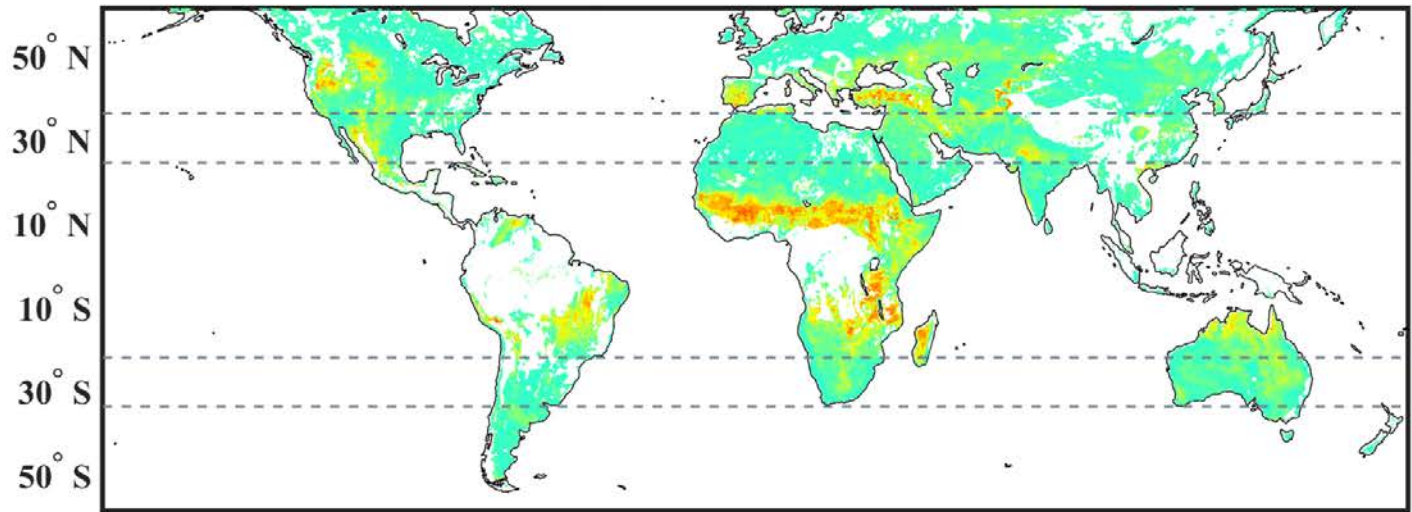
$$R^2[SM_{LSM}ET_{LSM}]$$



Direct coupling from multi-platform and LSMs

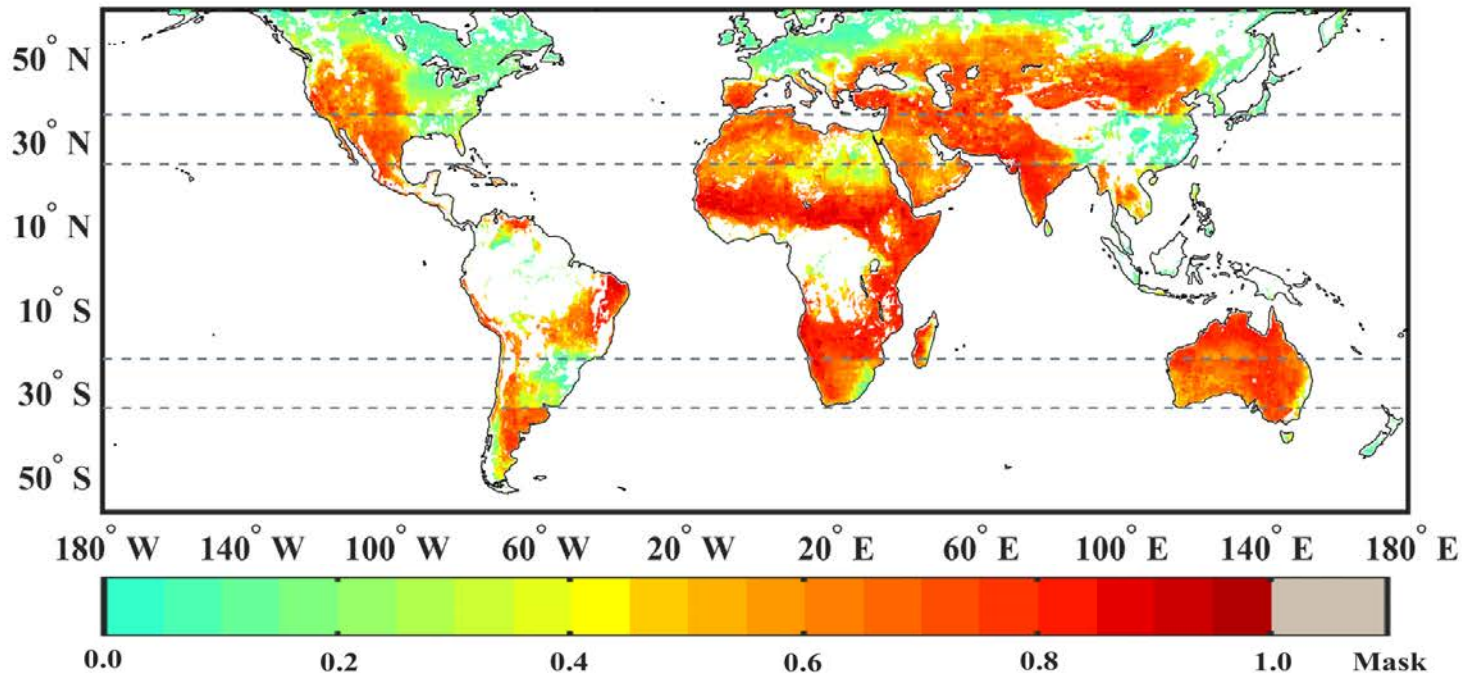
Remote Sensing

$$R^2[SM_{RS}ET_{RS}]$$



GLDAS LSMs

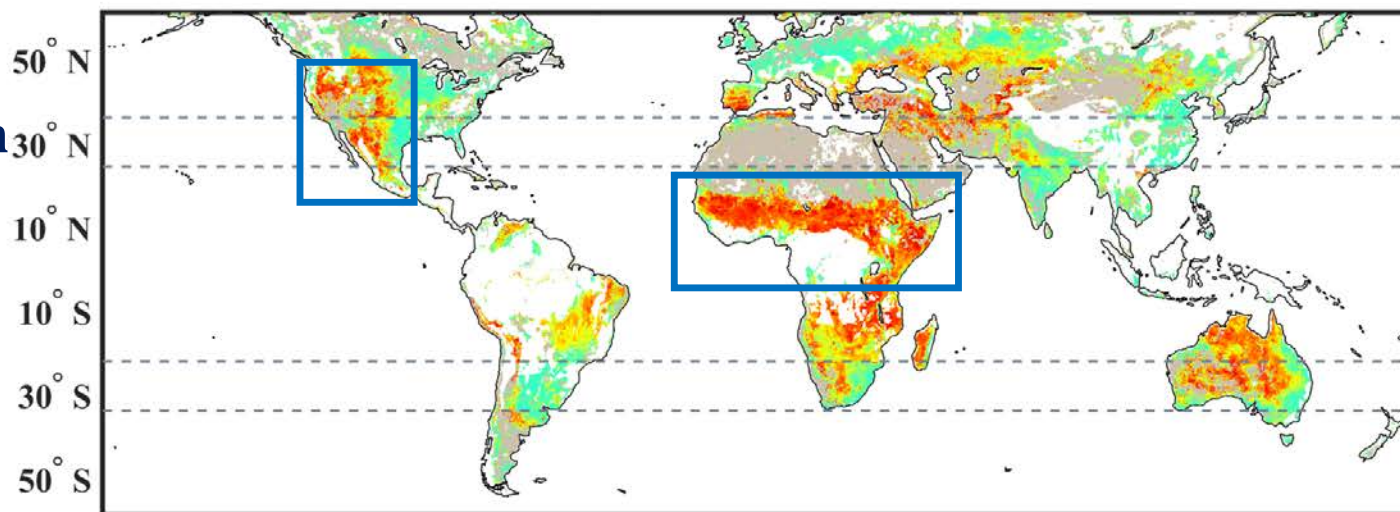
$$R^2[SM_{LSM}ET_{LSM}]$$



Integrated multi-platform based coupling

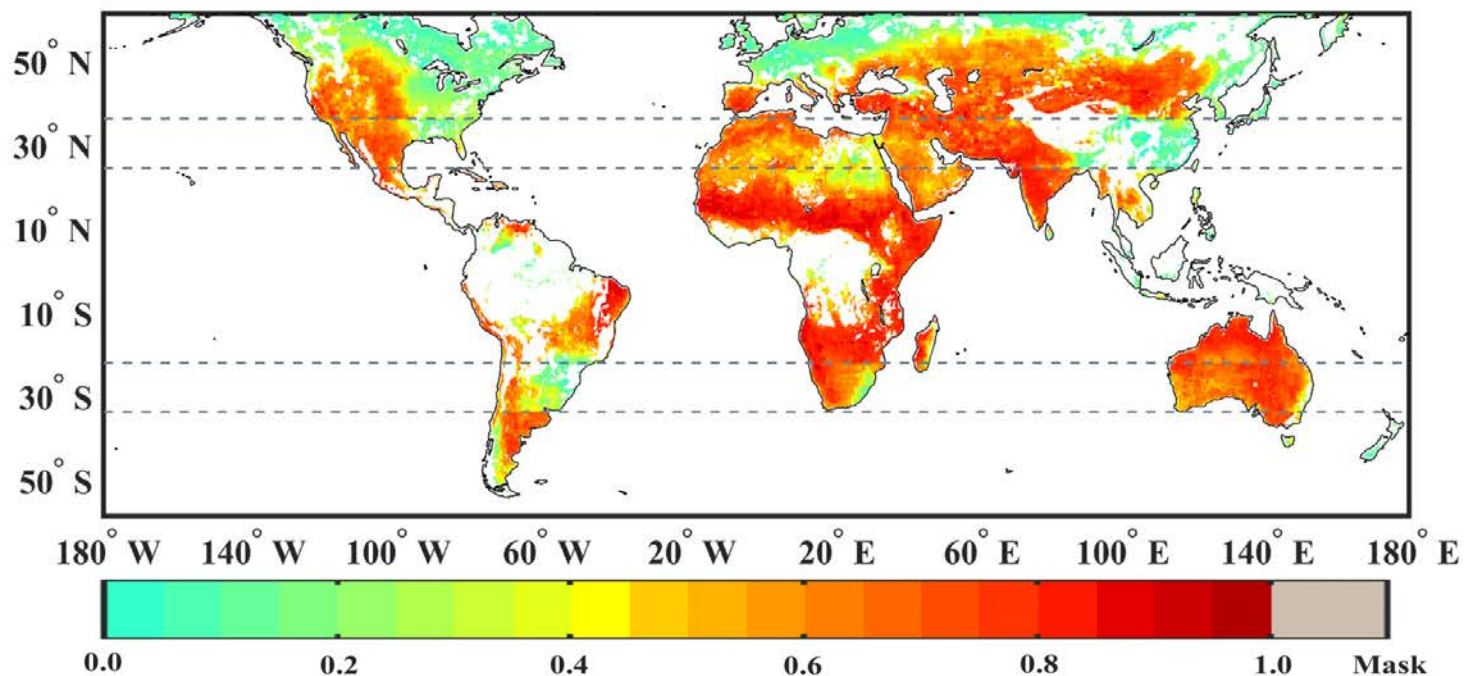
Triple Collocation

$$R^2[SM_{TC}ET_{TC}]$$



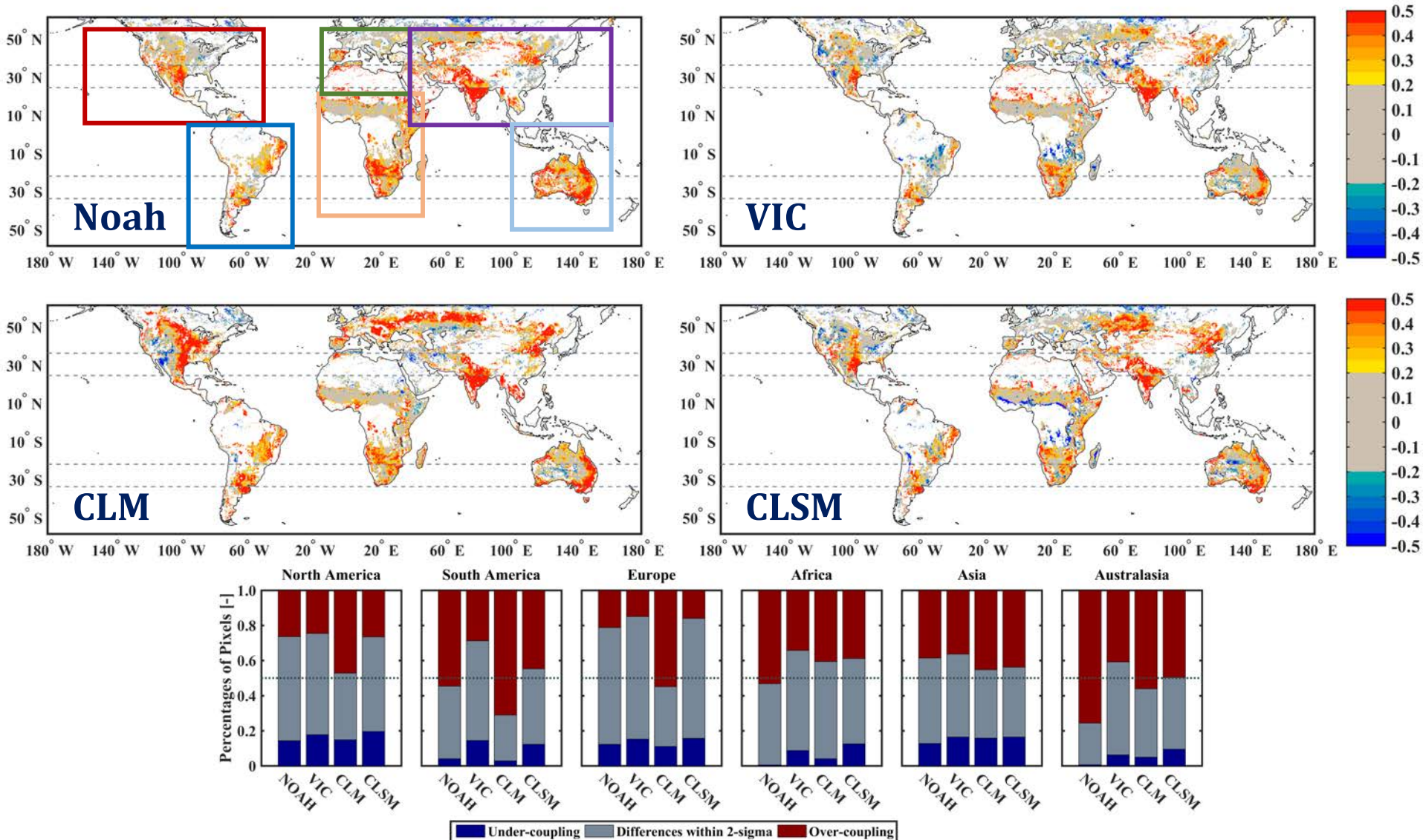
GLDAS LSMs

$$R^2[SM_{LSM}ET_{LSM}]$$

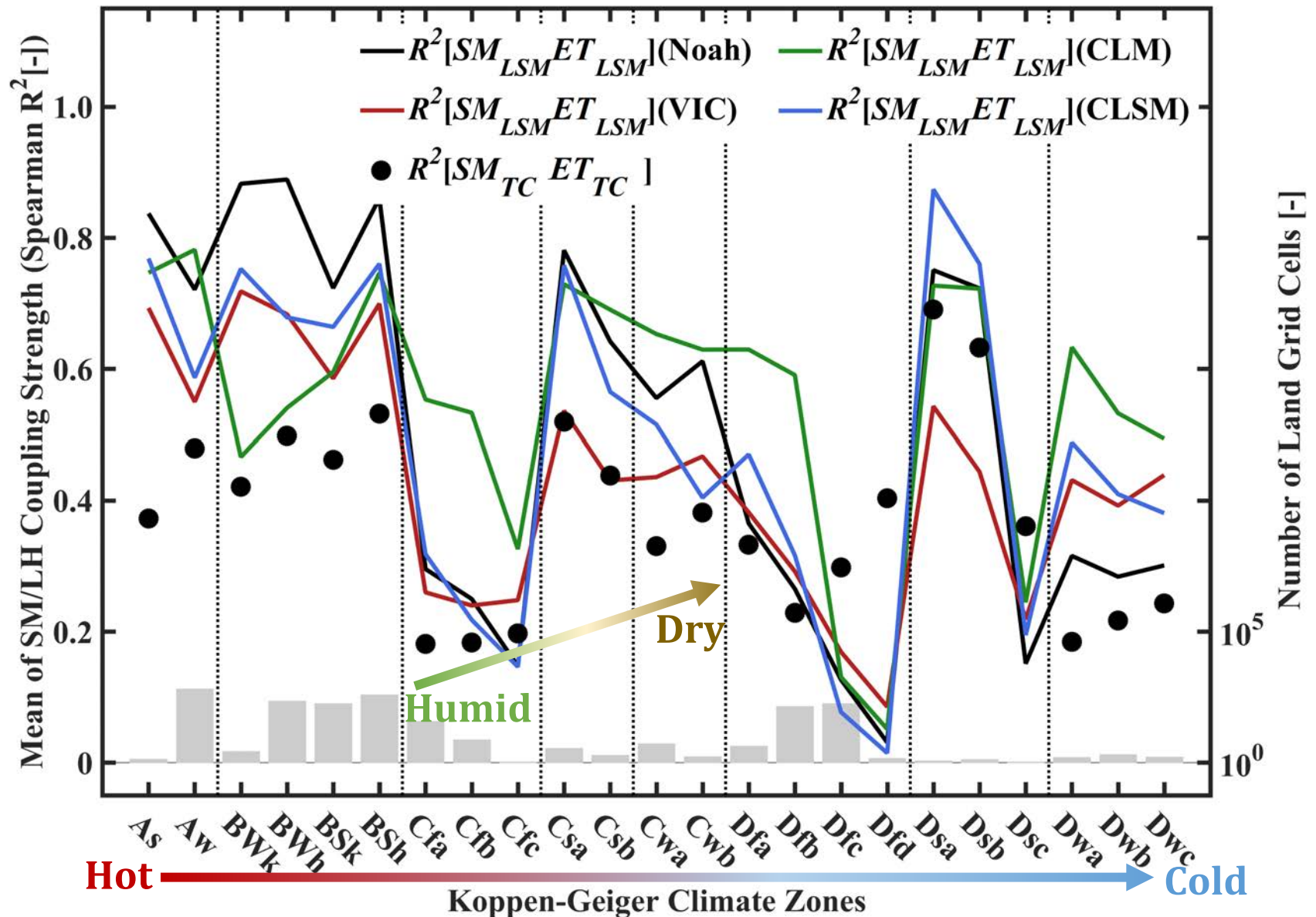


Benchmarking Land Surface Models

Biases in LSMs with regard to triple collocation-based estimates



Benchmarking Land Surface Models



Key Science Highlights

Here come the answers...



Random errors in remote sensing products impede the direct comparison



Large discrepancies exist among various land surface models



Land surface models generally overestimate the soil moisture/evapotranspiration coupling strength along transitional climate regimes

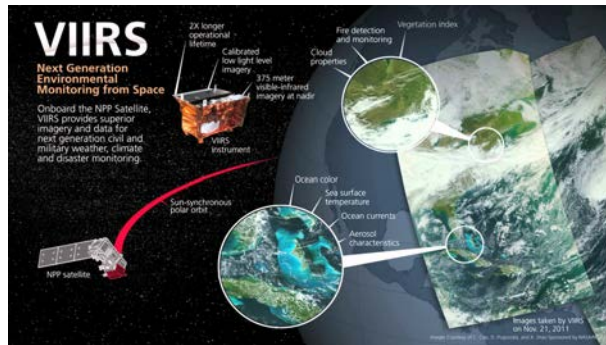
Published on Water Resources Research

F. Lei, W. T. Crow, T. R. H. Holmes, C. Hain, M. C. Anderson (2018), Global Investigation of Soil Moisture and Latent Heat Flux Coupling Strength, Water Resources Research, doi:10.1029/2018WR023469

On-going Development

ALEXI

TIR-LST

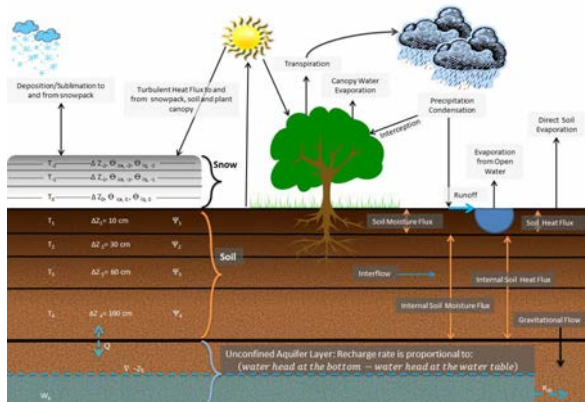


MW-LST



Land Surface Model

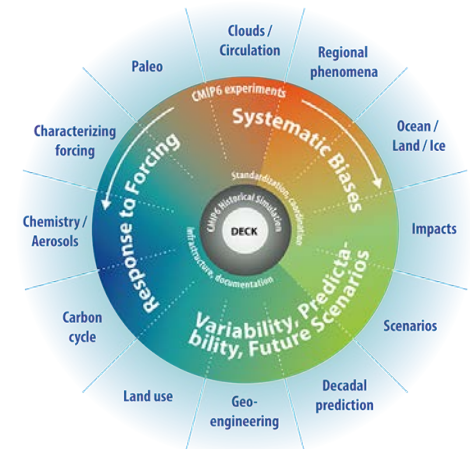
Noah-MP (modular)



from offline to coupled



CMIP5/6 LS3MIP



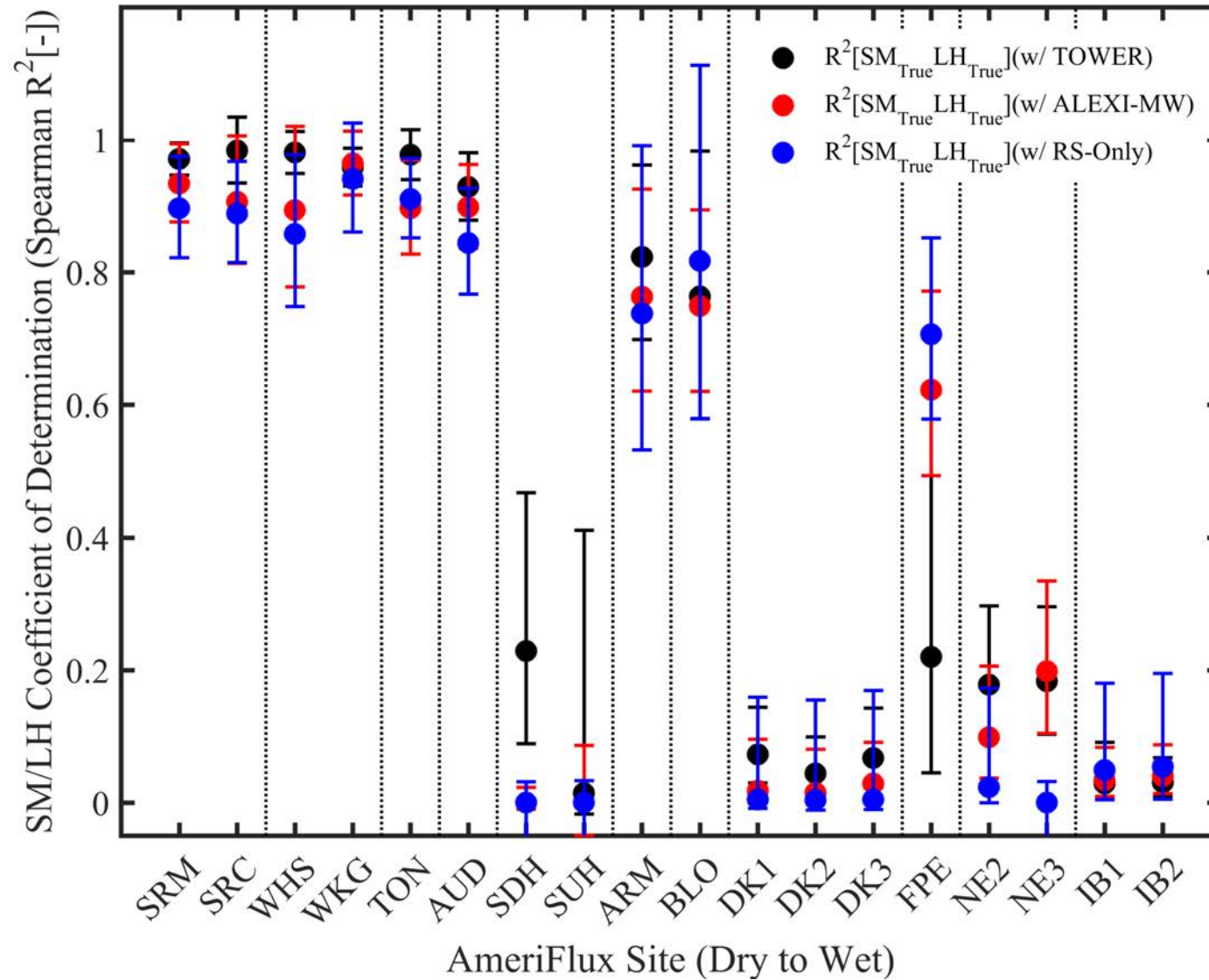
A collage of various satellites in orbit around Earth, with the text "Thank you!" centered in the middle. The satellites are shown in various orientations and positions, some with large solar panels and others with smaller components. The Earth's horizon is visible on the right side, and the background is a deep blue space with stars.

Thank you!

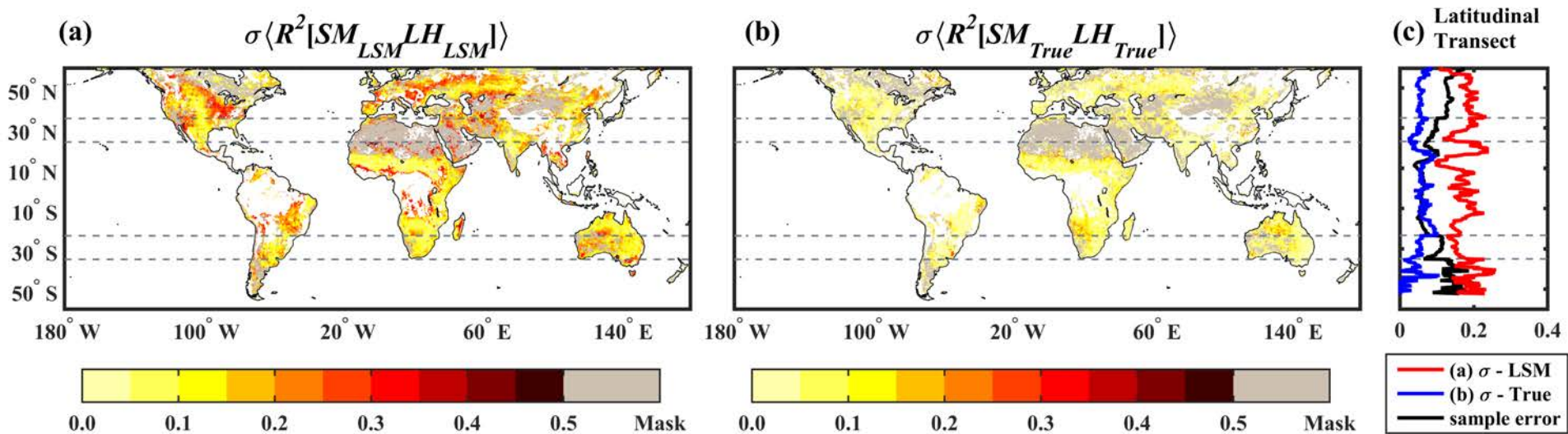
Back-up Slides



Back-up Slides



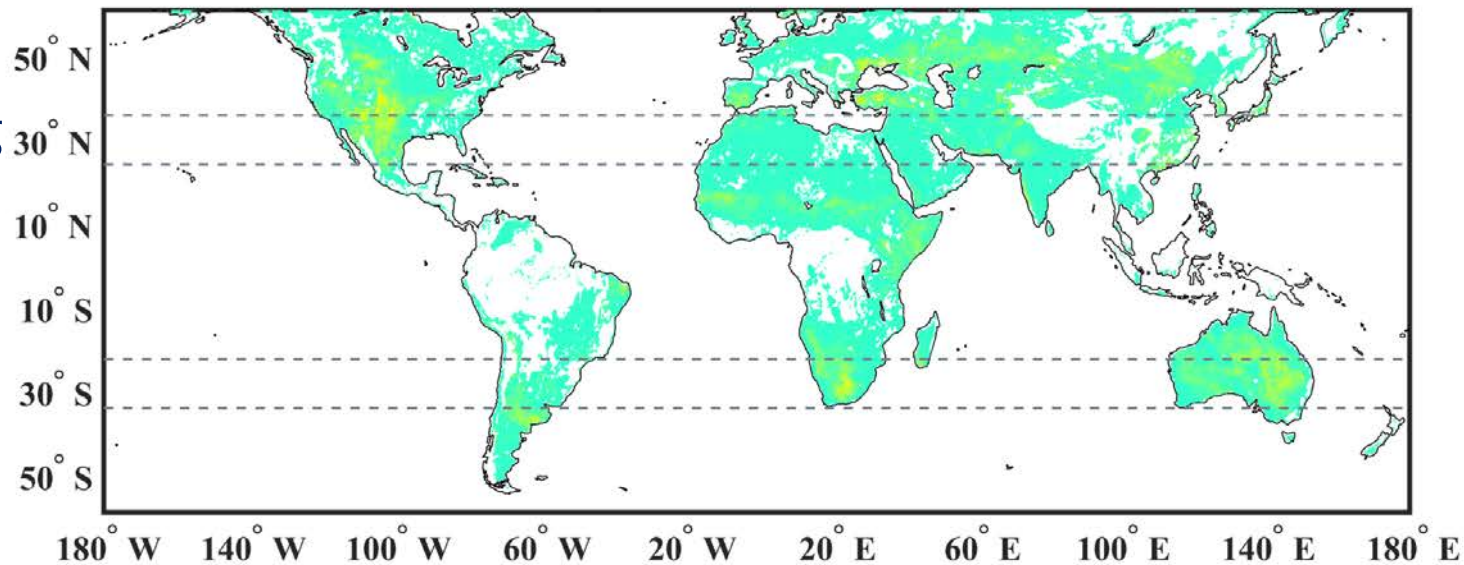
Back-up Slides



Back-up Slides

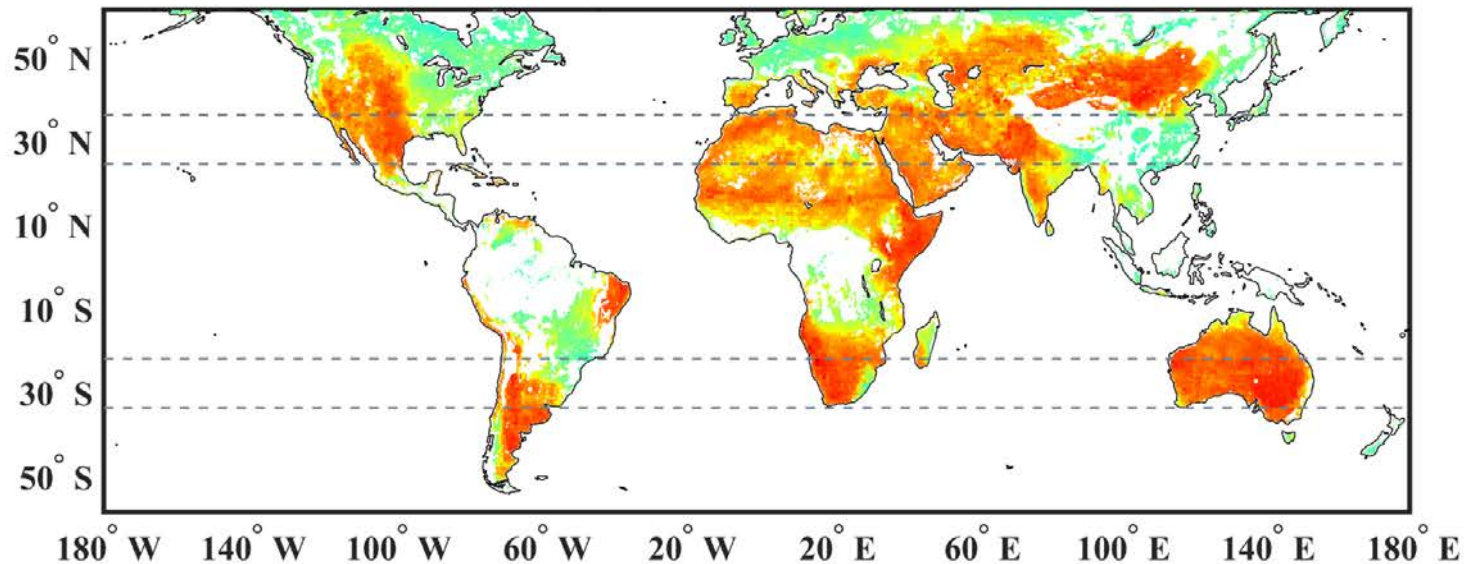
Remote Sensing

$$R^2[SM_{RS}ET_{RS}]$$



GLDAS LSMs

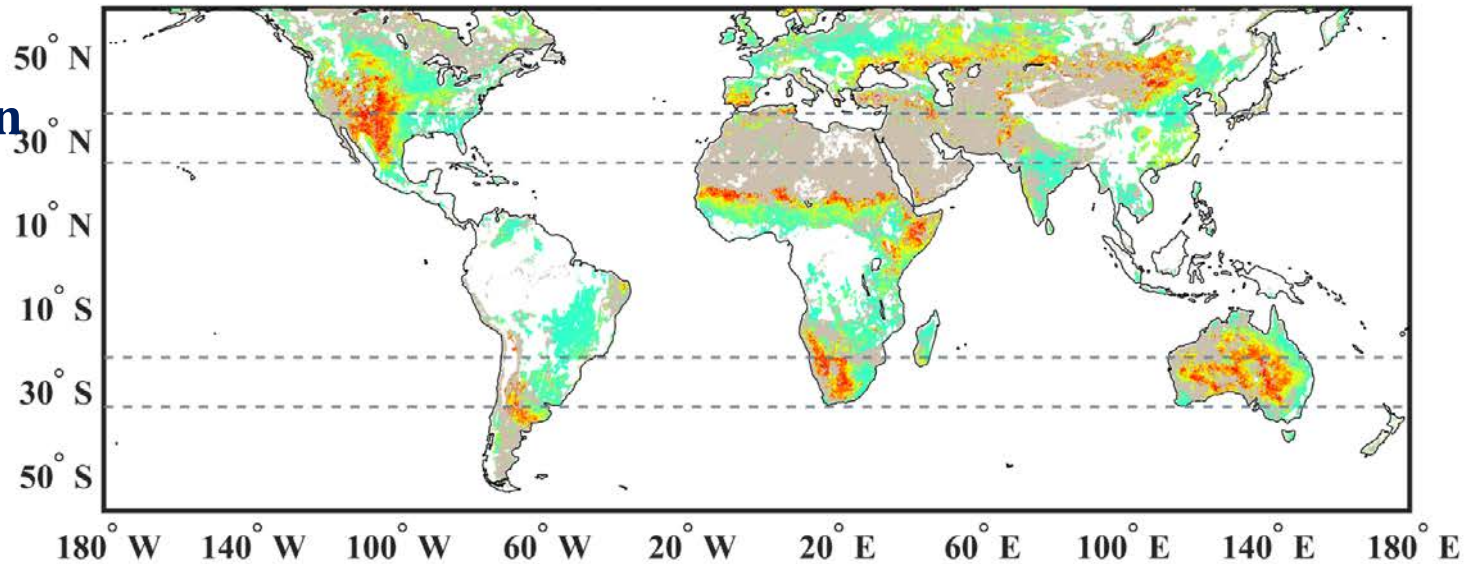
$$R^2[SM_{LSM}ET_{LSM}]$$



Back-up Slides

Triple Collocation

$$R^2[SM_{TC}ET_{TC}]$$



GLDAS LSMs

$$R^2[SM_{LSM}ET_{LSM}]$$

